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APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE: Tubular Heat Exchanger With Offset Interior Dimples

Tubular Heat Exchanger With Offset Interior Dimples

Description

Technical Field

This invention relates generally to heat exchangers used in furnaces and the like and in particular to a tubular heat exchanger having an interior structure to enhance the turbulence of combustion products flowing through the heat exchanger tubes.

Background Art

Heat exchangers used in furnaces and other heating apparatus are typically comprised of plural metal tubes, each of which may be bent in a serpentine fashion to form multiple passes for the flue gas flowing in each tube. The inlet of each tube is in communication with a burner assembly in which a combustible fuel-air mixture is burned. The outlet of each tube is in communication, either directly or indirectly through a secondary heat exchanger, with a flue vent or the like, whereby flue gas is exhausted from the heating apparatus. The flue gas flowing in the heat exchanger tubes transfers heat to air passing over the outside of the tubes, whereby air supplied to an indoor space is heated.

It is known in the art that heat transfer efficiency may be enhanced by slowing the flow of the gaseous products of combustion in the tubes and by increasing the turbulence thereof. One approach to accomplishing both of these results is to insert one or more baffles in the tubes to break up the laminar flow of the hot gas. Another approach is to flatten the tubes at certain locations to restrict and alter the flow of the gas. Yet another approach, as described in published United States patent application US 2002/0005275, is to extrude opposing pairs of dimples into the tube, so that the dimples of each pair are in alignment and form a pair of adjacent converging, diverging nozzles inside the tube.

Summary of the Invention

In accordance with the present invention, a tubular heat exchanger has at least one tube adapted to receive products of combustion in a furnace or other heating apparatus. The heat exchanger has at least one tube with an interior passageway and a wall surrounding the passageway. At least one pair of dimples projects from the wall into the passageway. The dimples are in generally facing relationship, but are offset from each other along a longitudinal axis of the tube.

In accordance with one embodiment of the invention, the tube has a generally circular cross-section and at least one of the dimples projects into the passageway beyond a centerline of the tube, so that at least one dimple projects inwardly by more than one-half of the diameter of the tube. In accordance with another embodiment of the invention, the dimples of each pair are offset from each other along the longitudinal axis of the tube by no more than one-half of the length of each dimple along the longitudinal axis. In accordance with yet another embodiment of the invention, both of the dimples of at least one pair of dimples project inwardly beyond the centerline of the tube. Each of the dimples is extruded into the passageway by deforming the tube wall and preferably defines a convex surface in the passageway.

Brief Description of Drawings

FIG. 1 is a general schematic view of a packaged air conditioning unit, comprised of a heating section, a cooling section and a condensing section;

FIG. 2 is a perspective view of a heat exchanger according to the present invention, used in the heating section of the unit of FIG. 1;

FIG. 3 is a side elevation view of one of the tubes in the heat exchanger of FIG. 2;

FIG. 4 is a sectional view, taken along the line 4-4 of FIG. 3; and

FIG. 5 is a sectional view, taken along the line 5-5 of FIG. 4.

Best Mode for Carrying Out the Invention

The best mode for carrying out the invention will now be described with reference to the accompanying drawings. Like parts are marked in the specification and drawings with the same respective reference numbers. In some instances, proportions may have been exaggerated in order to depict certain features of the invention.

Referring now to FIG. 1, a packaged gas heating/electric cooling unit **10** is depicted. Unit **10** includes cooling section **12**, a heating section **14** and a condensing section **16**, all of which are housed in a single metal cabinet **18**. Cooling section **12** includes an air filter **20**, an evaporator coil **22** and one or more compressors **23**. Heating section **14** includes a heat exchanger **24** and a supply air blower **26**, which is driven by an electric motor **27**. Blower **26** sits above heat exchanger **24** and when operated blows air downwardly through heat exchanger **24**. Condensing section **16** includes one or more condenser fans **28** and a condenser coil (not shown).

Referring also to FIG. 2, heat exchanger **24** has plural tubes **30** bent in a U-shaped configuration. An inlet end of each tube **30** communicates with one of a plurality of burners **32** and an outlet end of each tube **30** communicates with a header box **34** wherein flue products are collected after passing through tubes **30**. An induced draft blower **36** communicates with header box **34** for exhausting flue products from heat exchanger **24** to the atmosphere via a conduit **37** in the conventional manner.

When unit **10** is operated in a heating mode, burners **32** burn a combustible fuel-air mixture and the combustion products are drawn through tubes **30** by induced draft blower **36**. Supply air blower **26** draws the air to be heated from a return duct (not shown) into unit **10** through filter **20** to remove dirt and other debris therefrom and blows the air across heat exchanger tubes **30**, whereby heat is transferred through the tube walls from the flue products inside tubes **30** to the air flowing across the outside of heat exchanger **24**. Blower **26** blows the heated air from unit **10** into a supply duct (not shown), which communicates with an indoor space to be heated.

Evaporator coil **22**, condenser fans **28** and the condenser coil are inoperative in the heating mode.

When unit **10** is operated in a cooling mode, heat exchanger **24**, burners **32** and induced draft blower **36** are inoperative. A vapor compression refrigerant is circulated by one or more of the compressors **23** between evaporator coil **22** and the condenser coil in the conventional manner. The refrigerant is vaporized in evaporator coil **22**, which transfers heat from air drawn through coil **22** by supply air blower **26** to the refrigerant, thereby cooling the air. The cooled air is then blown through heating section **14** into the supply duct, which conducts the heated air to the indoor space.

Referring now to FIGS. 2 and 3, each tube **30** preferably has a circular cross-section with an outer diameter of about 2 inches. Tubes **30** are preferably made of a relatively thin wall of corrosive resistant metal material, such as aluminized steel, which circumscribes a hollow interior through which the flue products from burners **32** flow in the heating mode. Each tube **30** has an inlet end **30a** in communication with one of the burners **32** and an outlet end **30b** in communication with the header box **34**. The U-shaped configuration of tubes **30** causes the flue products in each tube **30** to make two passes through heat exchanger **24**. As can be best seen in FIG. 3, each tube **30** includes first and second leg portions **30c**, **30d** and a return bend portion **30e**. Leg portion **30c** communicates with a corresponding one of burners **32** and therefore represents an "upstream" leg of tube **30**, which corresponds to the first pass of the flue products through tube **30**. Leg portion **30d** communicates with header box **34** and therefore represents a "downstream" leg of tube **30**, which corresponds to the second pass of the flue products through tube **30**.

Each tube **30** has plural cooperating pairs of dimples **44** formed in the "downstream" leg **30d** thereof, at predetermined intervals (e.g., 4.25 inches) along leg **30d**. The "upstream" leg **30c** of the tube **30**, which corresponds to the first pass of the flue gas through tube **30** between inlet end **30a** and return bend portion **30e**, has a relatively smooth wall. As can be best seen in FIG. 5, the two dimples **44a**,

44b of each cooperating pair are in generally diametrically opposed relationship, but are offset from each other along a longitudinal axis of leg **30d**. In the preferred embodiment, the amount of offset between any cooperating pair of dimples **44** does not exceed one-half of the dimple length along the longitudinal axis of leg **30d**.

Each dimple **44** defines a generally convex protrusion into an interior passageway **48**. Dimples **44** preferably extend inwardly beyond a central longitudinal axis of passageway **48**, so that the dimples **44** of each cooperating pair may be in at least partial contact, as best seen in FIG. 5. For example, if tube **30** has an outer diameter of 2 inches, each dimple **44** may protrude approximately 1.03 inch into passageway **48**. Contact between the dimples **44** of each cooperating pair causes the flue gases to change directions and slows down their flow in passageway **48**, thereby increasing turbulence and enhancing heat transfer.

Dimples **44** preferably are punched into the wall of downstream leg **30c** of each tube **30** on the sides thereof so that there are no constrictions in the bottoms of tubes **30** to interfere with drainage of condensate therefrom. Specifically, each dimple **44** is preferably formed by deforming the tube wall inwardly by means of a spherical punching tool (not shown). The result of the punching process is a generally elliptical, concave indentation in the tube wall on the outside of the corresponding tube **30**, as can be best seen in FIG. 3, and a corresponding generally elliptical, convex protrusion inside the corresponding tube **30**, as can be best seen in FIGS. 4 and 5.

The best mode for carrying out the invention has now been described in detail. Since changes in and additions to the above-described best mode can be made without departing from the nature, spirit and scope of the invention, the invention is not to be limited to the above-described best mode, but only by the appended claims and their equivalents.